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Sato et al.

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(54) **ELECTROMAGNETIC INTERFERENCE SUPPRESSING BODY HAVING LOW ELECTROMAGNETIC TRANSPARENCY AND REFLECTION, AND ELECTRONIC DEVICE HAVING THE SAME**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/159,965**

(22) Filed: **Sep. 24, 1998**

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(62) Division of application No. 08/374,825, filed on Jan. 19, 1995, now Pat. No. 5,864,088.

(30) **Foreign Application Priority Data**

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Jun. 27, 1994 (JP) 6-144965
Aug. 16, 1994 (JP) 6-192399

(51) **Int. Cl.**^{7} **H05K 9/00**
(52) **U.S. Cl.** .... **174/35 MS**; 428/546
(58) **Field of Search** .... 174/35 R, 35 MS, 174/260; 361/816, 818, 799, 800; 257/659, 660; 252/62.58; 428/546

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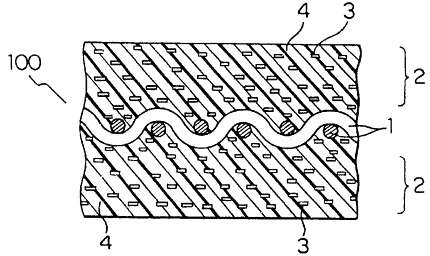
(74) *Attorney, Agent, or Firm*—Bradley N. Ruben

(57) **ABSTRACT**

An electromagnetic interference suppressing body is provided for suppressing electromagnetic interference by undesirable electromagnetic waves. The body includes a conductive support element and a non-conductive soft magnetic layer provided on at least one surface. The electromagnetic interference suppressing body may be used in an electronic equipment comprising a circuit board and an active element mounted on the circuit board, and is interposed between the circuit board and the active element so as to suppress the interference by an induction noise generated from the active element. The electromagnetic interference suppressing body may also be used in a hybrid integrated circuit element having an active element and a passive element mounted on a circuit board. The hybrid integrated circuit element is covered with and sealed by a non-conductive layer and the electromagnetic interference suppressing body overlying an outer surface of the non-conductive layer.

26 Claims, 11 Drawing Sheets



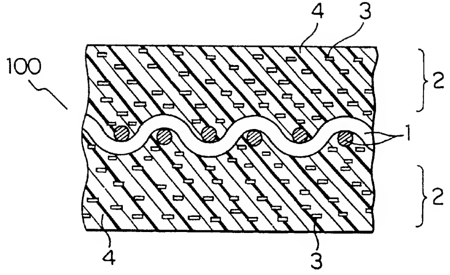


FIG. 1

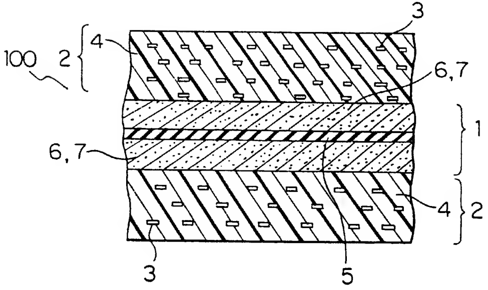


FIG. 2

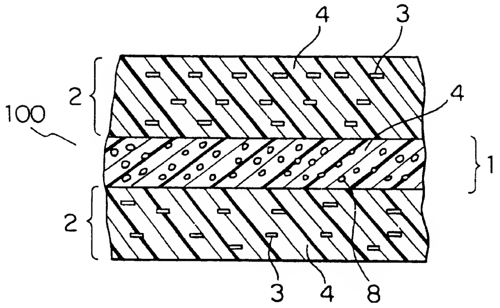


FIG. 3

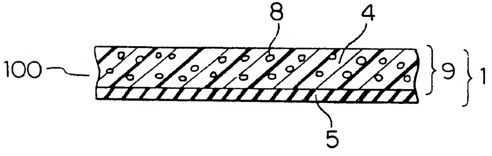


FIG. 4

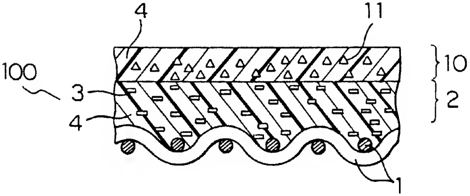


FIG. 5

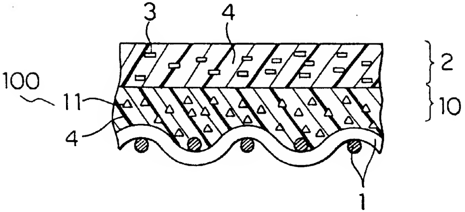


FIG. 6

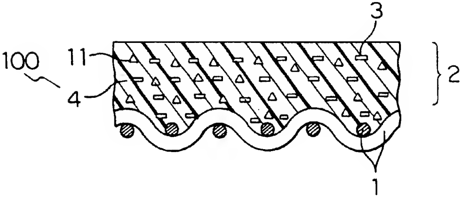


FIG. 7

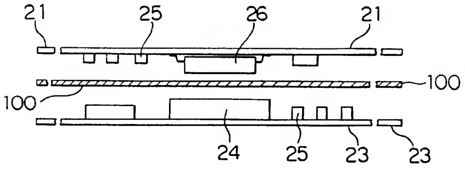


FIG. 8

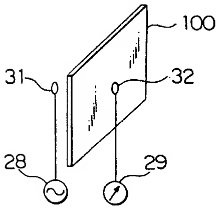


FIG. 9

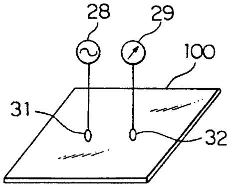


FIG. 10

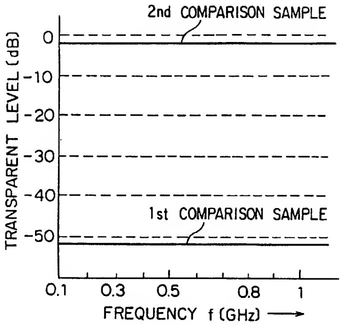

2nd COMPARISON SAMPLE
1st COMPARISON SAMPLE
TRANSPARENT LEVEL (dB)
0
-10
-20
-30
-40
-50
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 11

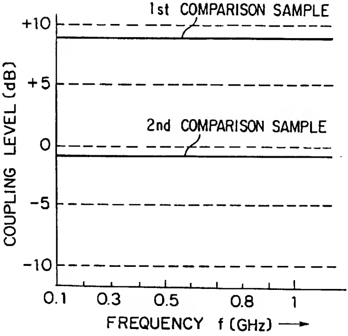

1st COMPARISON SAMPLE
2nd COMPARISON SAMPLE
COUPLING LEVEL (dB)
+10
+5
0
-5
-10
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 12

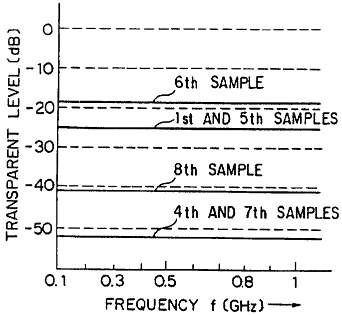

TRANSPARENT LEVEL (dB)
0
-10
-20
-30
-40
-50
6th SAMPLE
1st AND 5th SAMPLES
8th SAMPLE
4th AND 7th SAMPLES
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz) →

FIG. 13

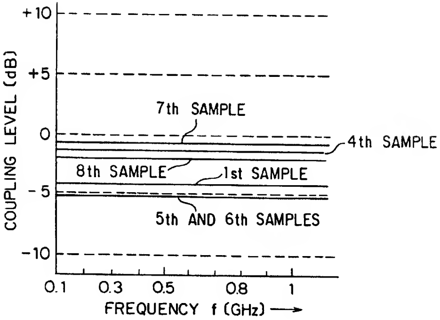

COUPLING LEVEL (dB)
+10
+5
0
- 5
-10
7th SAMPLE
4th SAMPLE
8th SAMPLE
1st SAMPLE
5th AND 6th SAMPLES
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz) →

FIG. 14

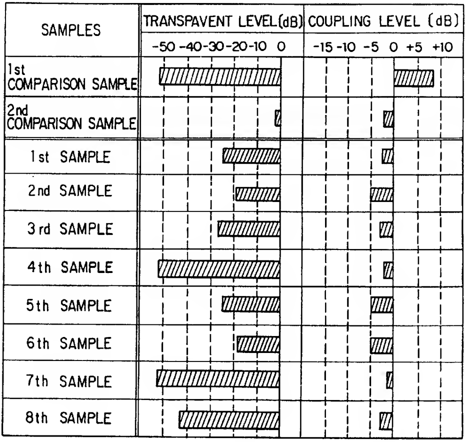

SAMPLES
TRANSPAVENT LEVEL(dB)
COUPLING LEVEL (dB)
-50 -40 -30 -20 -10 0
-15 -10 -5 0 +5 +10
1st COMPARISON SAMPLE
2nd COMPARISON SAMPLE
1st SAMPLE
2nd SAMPLE
3rd SAMPLE
4th SAMPLE
5th SAMPLE
6th SAMPLE
7th SAMPLE
8th SAMPLE

FIG. 15

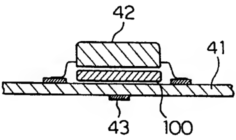

42
41
43
100

FIG. 16

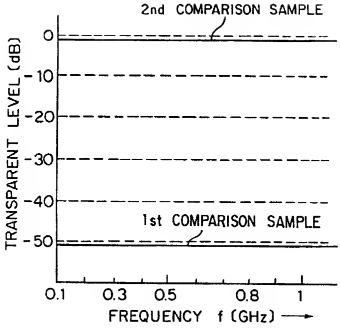

2nd COMPARISON SAMPLE
1st COMPARISON SAMPLE
TRANSPARENT LEVEL (dB)
0
-10
-20
-30
-40
-50
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 17

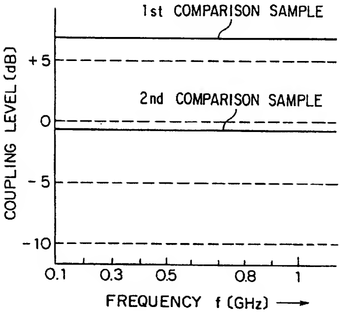

1st COMPARISON SAMPLE
2nd COMPARISON SAMPLE
COUPLING LEVEL (dB)
+5
0
-5
-10
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 18

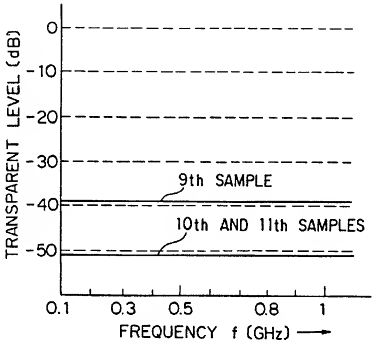

TRANSPARENT LEVEL (dB)
0
-10
-20
-30
-40
-50
9th SAMPLE
10th AND 11th SAMPLES
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 19

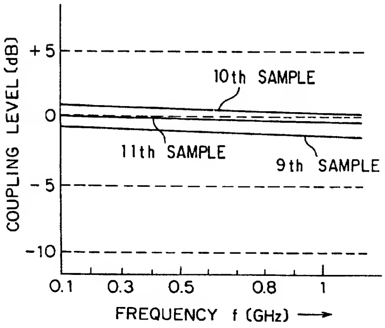

COUPLING LEVEL (dB)
+5
0
-5
-10
10th SAMPLE
11th SAMPLE
9th SAMPLE
0.1
0.3
0.5
0.8
1
FREQUENCY f (GHz)

FIG. 20

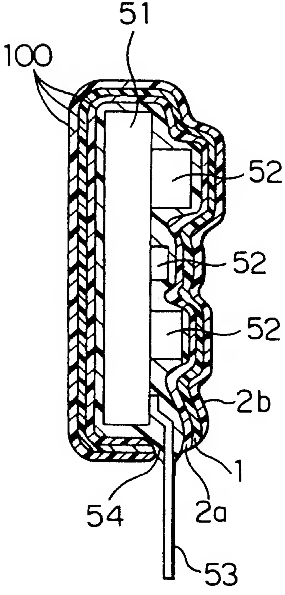


FIG. 21

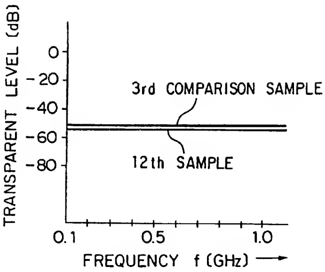

TRANSPARENT LEVEL (dB)
0
-20
-40
-60
-80
3rd COMPARISON SAMPLE
12th SAMPLE
0.1
0.5
1.0
FREQUENCY f (GHz)

FIG. 22

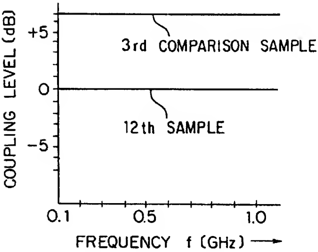

COUPLING LEVEL (dB)
+5
0
-5
3rd COMPARISON SAMPLE
12th SAMPLE
0.1
0.5
1.0
FREQUENCY f (GHz)

FIG. 23

ELECTROMAGNETIC INTERFERENCE SUPPRESSING BODY HAVING LOW ELECTROMAGNETIC TRANSPARENCY AND REFLECTION, AND ELECTRONIC DEVICE HAVING THE SAME

This is a division of application Ser. No. 08/374,825, filed Jan. 19, 1995, issued as U.S. Pat. No. 5,864,088.

BACKGROUND OF THE INVENTION

The present invention relates to an electromagnetic interference suppressing body for use in suppressing electromagnetic interference by any useless or undesired electromagnetic wave or waves, and also relates to an electric circuit device using the electromagnetic interference suppressing body.

In digital and/or high frequency electric circuit devices, small size and light weight are strongly desired and, therefore, electronic parts are required to be mounted on a printed circuit board as well as in an electric circuit device with a high density.

When electronic parts and wiring conductive lines are mounted on a circuit board, electromagnetic interference is caused by electrostatic and/or magnetic coupling between electronic parts and/or wiring conductive lines. Further, if a plurality of circuit boards are disposed adjacent to one another, electromagnetic interference is also caused between the adjacent circuit boards. In particular, the electromagnetic interference is severe when active elements such as semiconductor devices are mounted on the circuit board or boards because the active elements radiate undesired electromagnetic wave or inductive noise.

In the prior art, suppress of the electromagnetic interference was tried by means of connecting a low-pass filter or noise filter to each output terminal of the circuit board or by means of keeping a circuit in question at a distance. However, they require a space for disposing the filter or filters and/or a space for giving the distance. As a result, the device is made large in size and weight.

For suppressing electromagnetic coupling between adjacent circuit boards, a conductive shielding member was disposed between the circuit boards. However, the shielding member cannot prevent reflection of an undesired radiation from one circuit board, so that the reflection increases magnetic coupling between parts on the circuit board.

Hybrid integrated circuit elements are known as electronic circuit elements of a high density and a small size and are usually mounted on a mother board or boards in the electric circuit device. In the condition, the hybrid integrated circuit elements also suffer from electromagnetic interference.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an electromagnetic interference suppressing body with a low electromagnetic transparency and with a low electromagnetic reflcction which enables to electromagnetically shield a circuit board from another circuit board adjacent thereto as well as to suppress reflection of undesired radiation by the body to thereby suppress coupling between parts on the same circuit board even without use of low-pass filter or noise filter and even without a large distance between parts of circuit boards.

It is another object of the present invention to provide an electric circuit device having an electromagnetic interference suppressing body with a low electromagnetic transparency and with a low electromagnetic reflection disposed in a space between an electronic circuit part and a circuit board to thereby suppress coupling between the circuit part and a wiring line on extending on the circuit board.

Further, it is an object of the present invention to provide a hybrid integrated circuit element wrapped by an electromagnetic interference suppressing body with a low electromagnetic transparency and with a low electromagnetic reflection which is enable to suppress electromagnetic interference caused by any external elements and by any internal elements.

According to the present invention, an electromagnetic interference suppressing body for suppressing electromagnetic interference by undesired electromagnetic waves can be obtained which comprises a conductive support element and a non-conductive soft magnetic layer overlying at least one of surfaces of the conductive support element.

Further, according to the present invention, an electronic equipment can be obtained which comprises a circuit board having an active element thereon, the active element generating an inductive noise, wherein an electromagnetic interference suppressing body is interposed between the circuit board and the active element, the electromagnetic interference suppressing body comprising a conductive support element and a non-conductive soft magnetic layer overlying at least one of surfaces of the conductive support element.

Furthermore, according to the present invention, a hybrid integrated circuit element can also be obtained which has a circuit board, an active element and a passive element mounted on the circuit board, and which is characterized in that the active element, the passive element, and the circuit board are covered together with and sealed by an insulating layer, a non-conductive soft magnetic layer comprising soft magnetic powder and organic binder, and overlying an outer surface of the insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view partly showing an electromagnetic interference suppressing body according to a first embodiment of the present invention;

FIG. 2 is a sectional view partly showing, in a common structure, a conductive support element in an electromagnetic interference suppressing body according to a second and a third embodiments of the present invention;

FIG. 3 is a sectional view partly showing a conductive support element in an electromagnetic interference suppressing body according to a fourth embodiment of the present invention;

FIG. 4 is a sectional view partly showing a conductive support element in an electromagnetic interference suppressing body according to a fifth embodiment of the present invention;

FIG. 5 is a sectional view partly showing an electromagnetic interference suppressing body according to a sixth embodiment of the present invention;

FIG. 6 is a sectional view partly showing an electromagnetic interference suppressing body according to a seventh embodiment of the present invention;

FIG. 7 is a sectional view partly showing an electromagnetic interference suppressing body according to an eighth embodiment of the present invention;

FIG. 8 is a sectional view schematically showing an example of application of an electromagnetic interference suppressing body according to the present invention which is interposed between circuit boards;

FIG. 9 is a schematic view of an evaluating system for use in evaluation of a characteristic of the electromagnetic interference suppressing body and especially for measuring an electromagnetic transparent level therethrough;

FIG. 10 is a schematic view of an evaluating system for use in evaluation of a characteristic of the electromagnetic interference suppressing body and especially for measuring an electromagnetic coupling level;

FIG. 11 is a graph showing a frequency characteristic of electromagnetic transparent levels obtained by measuring comparison samples by use of the evaluating system shown in FIG. 9;

FIG. 12 is a graph showing a frequency characteristic of electromagnetic coupling levels obtained by measuring comparison samples by use of the evaluating system shown in FIG. 10;

FIG. 13 is a graph showing a frequency characteristic of electromagnetic transparent levels obtained by measuring samples of the present invention by use of the evaluating system shown in FIG. 9;

FIG. 14 is a graph showing a frequency characteristic of electromagnetic coupling levels obtained by measuring samples of the present invention by use of the evaluating system shown in FIG. 10;

FIG. 15 is a graph for showing transparent levels and coupling levels of comparison samples and samples of the present invention at a frequency of 800 MHz;

FIG. 16 is a sectional view of an electronic equipment using the electromagnetic interference suppressing body;

FIG. 17 is a graph showing a frequency characteristic of transparent levels obtained by measuring comparison samples by use of the evaluating system shown in FIG. 9;

FIG. 18 is a graph showing a frequency characteristic of coupling levels obtained by measuring comparison samples by use of with the evaluating system shown in FIG. 10;

FIG. 19 is a graph showing a frequency characteristic of transparent levels of obtained by measuring samples of the present invention by use of the evaluating system shown in FIG. 9;

FIG. 20 is a graph showing a frequency characteristic of coupling levels obtained by measuring samples of the present invention by use of the evaluating system shown in FIG. 10;

FIG. 21 is a sectional view of a hybrid integrated circuit using the electromagnetic interference suppressing body;

FIG. 22 is a graph showing a frequency characteristic of transparent levels obtained by measuring a comparison sample and a sample of the present invention by use of the evaluating system shown in FIG. 9; and

FIG. 23 is a graph showing a frequency characteristic of coupling levels obtained by measuring a comparison sample and a sample of the present invention by use of the evaluating system shown in FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, an electromagnetic interference suppressing body according to a first embodiment of the present invention is now described below. The electromagnetic interference suppressing body **100** shown therein comprises a conductive support element **1** and a non-conductive soft magnetic layer **2** mounted on or overlying at least one surface (two layers **2** are shown on both surfaces in FIG. 1). Non-conductive soft magnetic layer **2** comprises soft magnetic powder **3** of particles each of which has a flat shape of a needle-like shape, and organic binder **4** in which the soft magnetic powder **3** is uniformly dispersed.

For use as the conductive support element **1**, one element is selected from, for example, a conductive plate, a conductive mesh plate, and a textile of conductive fiber. The conductive support element **1** can have the soft magnetic property. For use as the conductive support element **1** with the soft magnetic property, one element is also selected from, for example, a soft magnetic metal plate, a soft magnetic metal netting plate, and a textile of a soft magnetic metal fiber.

In an electromagnetic interference suppressing body **100** according to a second embodiment of the present invention shown in FIG. **2**, conductive support element **1** with or without the soft magnetic property comprises a non-conductive or insulative base member **5** and a conductive thin layer **6** formed by evaporation on at least one surface of non-conductive base member **5**. Although two conductive thin layers **6** are shown on both surfaces in FIG. **2**, one conductive thin layer **6** may be formed on one surface of non-conductive base member **5**. Non-conductive soft magnetic layer **2** similar to the layer **2** shown in FIG. **1** provided to overlie the conductive thin layer **6**. In an electromagnetic interference suppressing body **100** according to a third embodiment of this invention, a soft magnetic thin metal layer **7** can be used in place of the conductive layer **6** in FIG. **2**. Although soft magnetic thin metal layer **7** is formed by evaporation on each of both surfaces of non-conductive base member **5**, a single soft magnetic thin metal layer **7** may be formed on one surface thereof.

In an electromagnetic interference suppressing body **100** according to a fourth embodiment of the present invention shown in FIG. **3**, conductive support element **1** comprises organic binder **4** and conductive powder **8** dispersed therein. Non-conductive soft magnetic layer **2** similar to the layer **2** shown in FIG. **1** overlies at least one surface of conductive support body **1**.

In an electromagnetic interference suppressing body **100** according to a fifth embodiment of the present invention shown in FIG. **4**, conductive support element **1** comprises non-conductive base member **5** and a conductive layer **9** overlying at least one surface of conductive layer **9**. Non-conductive soft magnetic layer similar to the layer **2** shown in FIG. **1** is formed to overlie at least one surface of conductive support body **1**.

Referring to FIG. **5**, an electromagnetic interference suppressing body **100***a* sixth and seventh embodiment of the present invention comprises conductive support element **1**, non-conductive soft magnetic layer **2** overlying at least one surface of conductive support body **1**, and a dielectric layer **10** overlying a surface of non-conductive soft magnetic layer **2**. Non-conductive soft magnetic layer **2** comprises soft magnetic powder **3** of particles, each of which has a flat shape or a needle-like shape, and organic binder **4**. Dielectric layer **10** includes dielectric powder **11** and organic binder **4**.

An electromagnetic interference suppressing body **100** shown as a seventh embodiment in FIG. **6** is similar to the sixth embodiment in FIG. **5**, but is different in that the dielectric layer **10** is interposed between conductive support body **1** and non-conductive soft magnetic layer **2**.

Referring to FIG. **7**, an electromagnetic interference suppressing body **100** shown as an eighth embodiment comprises conductive support element **1** and non-conductive soft magnetic layer **2** overlying at least one surface of conductive support body **1**. Non-conductive soft magnetic layer **2**

comprises soft magnetic powder **3** of particles, each of which has a flat shape or a needle-like shape, dielectric powder **11**, and organic binder **4**.

In the embodiments mentioned above, the conductive support element **1** is selected from a conductive plate, a conductive mesh plate, and a textile of conductive fiber. Further, the conductive support element **1** may have the soft magnetic property and can be selected from a soft magnetic metal plate, a soft magnetic metal mesh plate, and a textile of a soft magnetic metal fiber.

Examples used for conductive support body **1** are as follows: a thin metal plate such as a thin copper plate, a thin stainless plate, and a thin alminum plate, a so called, punched metal made of such a thin metal plates through which holes are punched, a, so called, expanded metal plate made of those thin metal plates through which slits are formed and expanded thereafter, and a metal grid or netting by making fiber conductors into a grid or net.

The conductive support element can have the soft magnetic property and is made of such materials as a permalloy or iron-silicon steel and the like into the similar shapes as described above. By use of this conductive support element **1**, it is expected to obtain high suppressing effect against the electromagnetic interference at relatively low frequency.

Typical materials of soft magnetic powder **3** are an iron-alminum-silicon alloy which is referred to as "SENDUST" (trademark) having a high permeability at a high frequency range and an iron-nickel alloy (permalloy). Soft magnetic powder **3** is used in a state that it is reduced to fine powder and oxidized at its surface. Further, it is desirable that an aspect ratio of soft magnetic powder **3** is high enough, for example, about more than 5:1.

The conductive support element **1** is also made of a sheet which is formed by metal powder such as silver powder and copper powder, conductive carbon black, or conductive titanium oxide mixed with and dispersed in organic binder.

Furthermore, it is possible to use conductive support element which comprises non-conductive base member **5**, for example, made of a polyimide base member and a conductive film of, for example, metal, magnetic metal conductive carbon, organic conductive material and others which is formed by evaporation on at least one of the surfaces thereof.

The conductive support element **1** is also made of a sheet which is formed by coating a polyimide base member **5** with the mixture of the metal powder, conductive carbon black, or conductive titanium oxide and the organic binder **4**, using a doctor blade method, a gravure coating method, a reverse coating method or the like.

As organic binder, the following materials are recommended; thermoplastic resins such as polyester resins, polyvinyl chloride resins, polyvinyl butyral resin, polyurethane resin, cellulose resins, nitrile-butadiene rubbers, styrene-butadiene rubbers and the like, copolymers of those thermoplastic resins or thermosetting resins such as epoxy resin, phenol resin, amide resins, imide resins and the like.

Non-conductive base member **5** is, for example, made of a polyimide base member on one side or both of which metal, magnetic metal, conductive carbon, organic conductive body or the like is deposited to form a thin layer using such deposition method as spattering, vacuum deposition, or chemical vapor deposition (CVD).

Further, it is desirable that dielectric layer **10** which is another element of the present invention described as the sixth embodiment or dielectric powder **11** used for non-conductive soft magnetic layer **2** has a high dielectric coefficient in a high frequency range and has a relatively flat frequency characteristic curve. For example, barium titanate series ceramics, titanium oxide-zirconium oxide series ceramics, lead perovskite series ceramics or the like is recommended.

The description will be made as to a test for evaluating properties of the electromagnetic interference suppressing body **100** according to the present invention.

Referring to FIG. **8**, an example of application of electromagnetic interference suppressing body **100** is supposed for the test. In the supposed application, two circuit boards **21** and **22** are disposed in parallel with each other and with a space left therebetween, and electromagnetic interference suppressing body **100** is disposed in the space with predetermined distances from respective circuit boards **21** and **22**.

Two circuit boards **21** and **22** are individually provided with a plurality of electronic parts such as shown at **24, 25** and **26** mounted on mounting surface of those circuit boards and are disposed so that the mounting surfaces face each other. The distance between an electronic part **24, 25,** or **26** on one circuit board and a facing one of electronic parts **24–26** on the other circuit board is about 2 mm but less than it.

FIGS. **9** and **10** show different systems for evaluating properties of the electromagnetic interference suppressing body **100** of the present invention in the supposed application, as shown in FIG. **8**. FIG. **9** shows an evaluating system for measuring the electromagnetic transparent level [dB] of the electromagnetic interference suppressing body **100**, and FIG. **10** shows another evaluating system for measuring the electromagnetic coupling level [dB] by the electromagnetic interference suppressing body **100**. Each of the systems is provided with an electromagnetic wave generator **28** and an electromagnetic field measuring instrument (a receiving element) **29** which use a small loop antenna for radiating electromagnetic field having a loop diameter of less than 2 mm and a small loop antenna for receiving electromagnetic field, respectively. A spectrum analyser (not shown) is used for measuring the values of the transparent and coupling levels.

The following is a detailed description of samples of electromagnetic interference suppressing body **100** of the present invention subjected to the evaluating test.

[First sample]

A first sample having a structure of FIG. **1** was obtained by using a stainless wire netting of 24 mesh as the conductive support element **1**, coating both side of the metal netting with a soft magnetic paste having a first composition described below by a doctor blade method to have a dried and cured total thickness of 1.2 mm, and performing curing for 24 hours at 85° C. The first sample thus obtained was analysed by use of a vibrating magnetometer and a scanning electron microscope, and it was confirmed that the directions of magnetization easy axis and magnetic particle alignment are in the surface of the sample.

<First composition>

Flat soft magnetic powder Composition: Fe-Al-Si alloy	90 weight parts
Average particle diameter	10 μm
Aspect ratio	>5

-continued

Organic binder	
Polyurethane resin	8 weight parts
Hardening agent (Isocyanate compound)	2 weight parts
Solvent (Mixture of cyclohexane and toluene)	40 weight parts

[Second sample]

A second sample having a structure of FIG. 1 was obtained in the similar manner to obtain the first sample, except that a permalloy (52Ni—Fe) wire netting of 24 mesh having soft magnetic property was used as a conductive support body 1, instead of using a stainless wire netting in the first sample.

[Third sample]

A third sample having a structure of FIG. 2 was obtained in the similar manner to obtain the first sample, except that the conductive support element 1 was used which comprised a polyimide film of 75 μm thickness and alminum layers of 3 μm thickness formed on both surfaces of the film by sputtering.

[Fourth sample]

A fourth sample having a structure of FIG. 2 was obtained in the similar manner to obtain the first sample, except that the conductive support element 1 was used which comprised a polyimide film of 75 μm thickness, and silver films formed by coating both surfaces of the polyimide film with a silver paste having a second composition described below by a doctor blade method to have a dried and cured thickness of 6 μm.

<Second composition>

Silver powder	95 weight parts
Average particle diameter	3 μm
Organic binder	
Polyvinyl butyral resin	4 weight parts
Hardening agent (Isocyanate compound)	1 weight parts
Solvent (Ethyl cellosolve)	35 weight parts

[Fifth sample]

A stainless wire netting of 24 mesh was used as a conductive support element 1. On both side of the stainless wire netting, a soft magnetic paste having a Third composition described below was coated by a doctor blade method so that the coating would have a total thickness of 1.0 mm after being dried and cured. Then, curing was carried out for 24 hours at 85° C. On the soft magnetic layer, a dielectric paste having a Fourth composition described below was coated by a doctor blade method to have a thickness of 100 μm after being dried and cured. A fifth sample having a structure of FIG. 5 was thus obtained.

The analysis of the fifth sample by use of the vibrating magnetometer and the scanning electron microscope revealed that the directions of magnetization easy axis and magnetic particle alignment were in the surface of the sample.

<Third composition>

Flat soft magnetic powder	90 weight parts
Composition: Fe-Al-Si alloy	
Average particle diameter	10 μm

-continued

Organic binder	
Polyurethane resin	8 weight parts
Hardening agent (Isocyanate compound)	2 weight parts
Solvent (Mixture of cyclohexane and toluene)	40 weight parts
<Fourth composition>	
Barium titanate powder	90 weight parts
Average particle diameter	7 μm
Organic binder	
Polyurethane resin	8 weight parts
Hardening agent (Isocyanate compound)	2 weight parts
Solvent (Mixture of cyclohexane and toluene)	45 weight parts

[Sixth sample]

A sixth sample having a structure of FIG. 7 was obtained by using stainless wire netting of 24 mesh as a conductive support element 1, coating both side surfaces of the wire netting with a soft magnetic paste having a Fifth composition described below by a doctor blade method to have a total thickness of 1.2 mm after being dried and cured, and performing curing for 24 hours at 85° C.

<Fifth composition>

Flat soft magnetic powder	70 weight parts
Composition: Fe-Al-Si alloy	
Average particle diameter	10 μm
Aspect ratio	>5
Barium titanate powder	20 weight parts
Average particle diameter	7 μm
Organic binder	
Polyurethane resin	8 weight parts
Hardening agent (Isocyanate compound)	2 weight parts
Solvent (Mixture of cyclohexane and toluene)	45 weight parts

[First comparison sample]

A copper plate having a thickness of 100 μm was used as a first comparison sample.

[Seventh sample]

A seventh sample having a structure of FIG. 1 was obtained by using a copper plate of 35 μm thickness as a conductive support element 1, coating both side surfaces of the copper plate with a soft magnetic paste having the First composition by a doctor blade method to have a total thickness of 1 mm, and performing curing for 24 hours at 85° C. The analysis of the seventh sample by use of the vibrating magnetometer and the scanning electron microscope revealed that the directions of magnetization easy axis and the magnetic particle alignment were in the surface of the sample.

[Eighth sample]

An eighth sample having a structure of FIG. 1 was obtained in the similar manner to obtain the First sample, except that a stainless wire netting of 120 mesh was used as a conductive support element 1 instead of using the stainless wire netting of 24 mesh in the first sample.

[Second comparison sample]

A second comparison sample was obtained by mixing 80 weight parts of iron powder of ball like particles with an average particle diameter of 30 μm into 20 parts of nitrile rubber, and kneading and forming the mixture into a sheet having a thickness of 1.2 mm.

The electromagnetic transparent levels and the electromagnetic coupling levels of the first to eighth samples and

the first to second comparison samples were measured by use of the evaluating systems shown in FIGS. **9** and **10**. The measured data are shown in FIGS. **11**, **12**, **13** and **14**. FIG. **11** shows frequency characteristics of the electromagnetic transparent levels of the first and second comparison samples. Here, the standard of the transparent level is selected to be the strength of electromagnetic field measured at **29** in FIG. **9** when electromagnetic interference suppressing body **100** is not used in FIG. **9**. FIG. **12** shows a frequency characteristics of the coupling levels of the first and second comparison samples. Here, the standard of the coupling level is selected to be the strength of electromagnetic field measured at **29** in FIG. **10** when electromagnetic interference suppressing body **100** is not used in FIG. **10**.

FIG. **13** shows frequency characteristics of the electromagnetic transparent levels of the first to eighth samples. Here, the standard of the transparent level is selected to be the strength of electromagnetic field measured at **29** in FIG. **9** when the electromagnetic interference suppressing body **100** is not used in FIG. **9**. FIG. **14** shows a frequency characteristics of the coupling levels of the first through eighth samples. Here, the standard of the coupling level is selected to be the strength of electromagnetic field measured at **29** in FIG. **10** when electromagnetic interference suppressing body **100** does not exist in FIG. **10**.

FIG. **15** shows the transparent and the coupling levels of first to eighth samples and first to second comparison samples at a frequency of 800 MHz. As is seen from FIGS. **11**, **12**, and **15**, the conductor (a copper plate) of the first comparison sample increases the coupling level, but lowers the transparent level. The second comparison sample does not almost attenuate the electromagnetic wave transparent therethrough, although it has a tendency to low the coupling level. That is, the second comparison sample is extremely low in the electromagnetic interference suppressing property.

On the contrary, the electromagnetic interference suppressing body **100** of the first to eighth samples according to the present invention are sufficiently low in the transparent level and in the coupling level as seen from FIGS. **13**, **14**, and **15**. Accordingly, it can be seen in FIG. **8** that the two circuit boards **21** and **23**, on which a plurality of electronic parts **24**, **25** and **26** are mounted, are protected from electromagnetic interference from each other an in individual boards by the electromagnetic interference suppressing body **100** disposed in the space between two circuit boards **21** and **23**.

It should be noted that the electromagnetic interference suppressing body **100** can suppress the electromagnetic interference in various high frequency electronic equipments including mobile communication equipments, since it ensures large attenuation for the electromagnetic radiation transparent therethrough without increasing the reflection of the undesired radiation.

Further, electromagnetic interference suppressing body **100** described in the embodiments can readily be make to have flexibility as seen from its construction so that it may comply with a complicated shape, anti-vibration or anti-shock requirements.

FIG. **16** shows an electronic equipment according to another embodiment which uses the electromagnetic interference suppressing body **100**. The electronic equipment has an LSI **42** of an active element mounted on a circuit board **41** and a wiring conductor **43** printed on the other side of the board **41**. The wiring conductor **43** extends below LSI **42**. The electromagnetic interference suppressing body **100** having the same size and about half thickness as LSI **42** is mounted between LSI **42** and circuit board **41**.

The electromagnetic interference suppressing body **100** is fixed to one of LSI **42** and the circuit board **41** before LSI **42** is mounted on the board **41**. Electromagnetic interference suppressing body **100** effectively suppresses noises generated at wiring conductor **43** by reducing induction coupling between LSI **42** and circuit conductor **43**, since the electromagnetic interference suppressing body **100** absorbs magnetic flux of a high frequency electromagnetic radiation generated by LSI **42**.

Supposing the electronic equipment in FIG. **16**, properties of the the electromagnetic interference suppressing body **100** were evaluated by use of the systems shown in FIGS. **9** and **10**.

Samples subjected to the evaluation test are ninth through eleventh samples described below.

[Ninth sample]

The ninth sample has the same structure as shown in FIG. **1** and was obtained by using stainless wire netting of 120 mesh as a conductive support element **1**, coating both sides of the netting with a soft magnetic paste having the first composition described above by a doctor blade method to have the total thickness of 0.5 mm after being dried and cured, and performing curing for 24 hours at 85° C. The ninth sample was analysed by use of the vibrating magnetometer and the scanning electron microscope. Thus, it was confirmed that the directions of the magnetization easy axis and the magnetic particle alignment were in the surface of the sample.

[Tenth sample]

The tenth sample having a structure of FIG. **2** was obtained in the similar manner to obtain the ninth sample, except that a polyimide film of 75 μm thickness having 3 um thick aluminum layers formed on both surfaces thereof by sputtering was used as the conductive support element **1**.

[Eleventh sample]

The eleventh sample having a structure of FIG. **2** was obtained in the similar manner to obtain the ninth sample, except that the conductive support element **1** was a 75 μm thick polyimide film, on both surfaces of which a silver paste having the second composition described above was coated by a doctor blade method to have 6 μm thickness after being dried and cured.

The first and second comparison samples were also evaluated.

The electromagnetic transparent levels and the electromagnetic coupling levels of the ninth to eleventh samples and the first to second comparison samples were measured by use of the evaluating systems shown in FIGS. **9** and **10**. The measured data are shown in FIGS. **17–20**. FIG. **17** shows frequency characteristics of the electromagnetic transparent levels of the first and second comparison samples. Here, the standard or the transparent level is selected to be the strength of electromagnetic field measured at **29** in FIG. **9** when electromagnetic interference suppressing body **100** is not used in FIG. **9**. FIG. **18** shows a frequency characteristics of the coupling levels of the first and second comparison samples. Here, the standard of the coupling level is selected to be the strength of electromagnetic field measured at **29** in FIG. **10** when electromagnetic interference suppressing body **100** is not used in FIG. **10**.

FIG. **19** shows frequency characteristics of the electromagnetic transparent levels of the ninth to eleventh samples. Here, the standard of the transparent level is selected to be the strength of electromagnetic field measured at **29** in FIG. **9** when the electromagnetic interference suppressing body **100** is not used in FIG. **9**. FIG. **20** shows a frequency characteristics of the coupling levels of the ninth through

eleventh samples. Here, the standard of the coupling level is selected to be the strength of electromagnetic field measured at 29 in FIG. 10 when electromagnetic interference suppressing body **100** does not exist in FIG. **10**.

As is seen from FIGS. **17** and **18**, the conductor (a copper plate) of the first comparison sample increases the coupling level to a value of +7 dB, but lowers the transparent level of −50 dB. The second comparison sample has the transparent level of about −1 dB and does not almost attenuate the electromagnetic wave transparent therethrough, although it has a tendency to low the coupling level of 0 dB.

On the contrary, the ninth to eleventh samples of the electromagnetic interference suppressing body **100** according to the present invention are sufficiently low in the transparent level of about −39 dB and in the coupling level of +1 dB, as seen from FIGS. **19** and **20**.

It should be noted that the electromagnetic interference suppressing body **100** can suppress the electromagnetic interference without affection by the reflection of undesired radiation in various electronic equipments in which electronic parts are mounted on a printed circuit board as shown in FIG. **16**. Further, since the electromagnetic interference suppressing body **100** is produced with a thin type plant, electronic equipments can be made smaller in size, lighter in weight, and low in cost although it has the suppressing properties against the electromagnetic interference.

FIG. **21** shows an embodiment of a hybrid integrated circuit element using electromagnetic interference suppressing body **100**. The hybrid integrated circuit element comprises a circuit board **51**, parts **52** such as an active element, passive element or the like mounted on circuit board **51**, and connection lead wires **53** for connecting those parts **52** to external equipments. An outer surface of the hybrid integrated circuit element is covered with a dielectric coating layer **54** such as resin or the like. In the hybrid integrated circuit element, the outer surface of dielectric coating layer **54** is covered with an electromagnetic interference suppressing body **100** shown in FIG. **3** without contacting with lead wire **53**. The electromagnetic interference suppressing body **100** comprises a conductive support element **1** which is coated with a first non-conductive soft magnetic layer ***2a*** and a second non-conductive soft magnetic layer ***2b*** on both sides thereof, respectively.

The first dielectric soft magnetic layer ***2a***, the conductive support element **1** and the second non-conductive soft magnetic layer ***2b*** are formed by a, so called, slurry impregnating method in which the hybrid integrated circuit element is dipped into a soft magnetic slurry and a conductive slurry, alternatingly. The soft magnetic slurry and the conductive slurry are made by mixing a soft magnetic powder **3** and a conductive powder **8** with organic binder to form mixtures and by kneading the mixtures to disperse the powder into the binder, respectively. Here, as the soft magnetic powder **3** included in the first and second non-conductive soft magnetic layers ***2a*** and ***2b***, iron-aluminium-silicon alloy which is known as "Sendust" (trademark), and iron-nickel alloy (permalloy) can be used. Further, the soft magnetic body powder **3** is used after being ground into fine powder and surface-oxidized. It is desirable that the aspect ratio of these powders is sufficiently large (about more than 5:1). Further, as the conductive powder **8** included in the conductive support element **1**, metal fine powder such as copper powder and silver powder, conductive carbon black powder or conductive titanium oxide powder can be used.

Furthermore, the thickness of the non-conductive soft magnetic layers ***2a*** and ***2b*** and the conductive support element 1 and constituent materials are determined to realize an optimum electromagnetic condition taking circuit conditions of the hybrid integrated circuit element, an arrangement of electronic parts to be mounted and the intensity of the undesired electromagnetic field and the like into consideration.

Supposing the hybrid integrated circuit element in FIG. **21**, properties of the electromagnetic interference suppressing body **100** were evaluated by use of the systems shown in FIGS. **9** and **10**. The following twelfth sample and third comparison sample were subjected to the evaluating test.

[Twelfth sample]

The first and the second non-conductive soft magnetic layers ***2a*** and ***2b*** having a sixth composition as described below were formed on both side surfaces of the conductive support element **1** having a seventh composition described below by the slurry dipping method to produce the twelfth sample having a structure of FIG. **3**.

<Sixth composition>

Flat soft magnetic powder	90 weight parts
Composition: Fe-Al-Si alloy	
Average particle diameter	10 μm
Aspect ratio	>5
Organic binder	
Polyurethane resin	8 weight parts
Hardening agent (Isocyanate compound)	2 weight parts
Solvent (Mixture of cyclohexane and toluene)	40 weight parts
Ethyl cellosolve	45 weight parts
<Seventh composition>	
Silver powder	95 weight parts
Average particle diameter	3 μm
Organic binder	
Polyvinyl butyral resin	4 weight parts
Hardening agent (Isocyanate compound)	1 weight parts
Solvent (Ethyl cellosolve)	75 weight parts

[Third comparison sample]

A third comparison sample was obtained with 100 μm thickness by coating both sides of a polyimide film of 75 μm thickness with silver paste having the seventh composition, using the slurry dipping method and by drying and hardening the paste.

FIGS. **22** and **23** show the results of the electromagnetic transparent level and the electromagnetic coupling level as measured.

It is clear from FIGS. **22** and **23** that the third comparison sample is sufficient low in the transparent level, but is high in the coupling level. In twelfth sample, on the contrary, the transparent level is sufficiently low and the coupling level is not increased but low. This means that the hybrid integrated circuit element according to the embodiment has a sufficient shielding effect against electromagnetic waves as the conventional element coated with the silver paste and does not have any reflection of electromagnetic waves which has been seen in the conventional element.

Now, description will be made as to a test for evaluating the electromagnetic suppressing properties of the hybrid integrated circuit element in an actual use. For the test, an outer surface of the hybrid integrated circuit element sealed by resin was coated with a first non-conductive soft magnetic layer ***2a***, a conductive support body **1** and a second non-conductive soft magnetic layer ***2b*** laminated one on another in this order using the slurry dipping method. After these layers were cured or hardened, the thickness of these three layers were measured to be 0.7 mm. These first and

second non-conductive soft magnetic layers **2***a* and **2***b* were analyzed with the vibrating magnetometer and the scanning electron microscope. Both directions of the magnetization easy axis and the magnetic particle alignment are in the surface of the sample.

Furthermore, thc hybrid integrated circuit element was mounted on the mother board and the operation of electric circuit was observed. No adverse effect was confirmed.

As described above, the hybrid integrated circuit element coated with the dielectric soft magnetic layers and the conductive support element is neither affected by any undesired radiation nor enhance the electromagnetic coupling by reflection when the element is mounted on the mother board.

According to the present invention in which the outer surface of the hybrid integrated circuit element sealed by resin is provided with first non-conductive soft magnetic layer, a hybrid integrated circuit element is obtained having a sufficient shielding effect against radiant electromagnetic waves from the mother board or other parts mounted on the mother board without enhancing the electromagnetic coupling between the inner parts or between the parts mounted on the mother board and without impeding its own operation. In particular, it is considerably advantageous to combine non-conductive soft magnetic layers **2***a*, **2***b* and conductive support element **1**.

Although the present invention is described with reference to several embodiments, it is needless to say that the present invention is not limited to the above embodiments and various variations are possible without departing from the spirit of the invention.

What is claimed is:

1. An electromagnetic interference suppressing body for suppressing electromagnetic interference by undesirable electromagnetic waves, comprising a conductive support element and a non-conductive soft magnetic layer overlying at least one of the surfaces of said conductive support element,

Said non-conductive soft magnetic layer comprising soft magnetic powder with organic binder, said soft magnetic powder being at least one selected from the group consisting of flat and needle-like powder dispersed in said organic binder, said soft magnetic powder being aligned parallel to said supporting element within said non-conductive soft magnetic layer, and wherein said soft magnetic powder comprises iron and at least one of nickel, aluminum, and silicon, each of the particles oxidized at its surface.

2. An electromagnetic interference suppressing body claimed in claim **1**, which further comprises a dielectric layer overlying said non-conductive soft magnetic layer.

3. An electromagnetic interference suppressing body claimed in claim **1**, which further comprises a dielectric layer interposed between said conductive support element and said non-conductive soft magnetic layer.

4. An electromagnetic interference suppressing body claimed in claim **1**, wherein said non-conductive soft magnetic layer further comprises dielectric powder.

5. An electromagnetic interference suppressing body claimed in claim **2** or **3**, wherein said dielectric layer comprises dielectric powder and organic binder.

6. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element is one selected from a conductive plate, a wire netting conductive plate, and a textile made of conductive fiber.

7. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element comprises a non-conductive base member and a conducive layer overlying at least one surface of said non-conductive base member.

8. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element comprises a non-conductive base member and a soft magnetic metal thin layer overlying at least one of surfaces of said non-conductive base member.

9. An electromagnetic interference suppressing body claimed in claim **7** or **8**, wherein said non-conductive base member is made of one of a non-conductive soft magnetic layer and a dielectric layer.

10. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element comprises conductive fine powder and organic binder.

11. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element comprises a non-conductive base member and a conductive layer overlying at least one of surfaces of said non-conductive base member, said conductive layer comprises conductive fine powder and organic binder.

12. An electromagnetic interference suppressing body claimed in claim **1**, wherein said conductive support element is a conductive soft magnetic support element having soft magnetic property.

13. An electromagnetic interference suppressing body claimed in claim **12**, wherein said conductive soft magnetic support element is one selected from a soft magnetic metal plate, a wire netting metal plate, and a textile made of soft magnetic metal fiber.

14. An electronic equipment comprising a circuit board having an active element thereon, said active element generating an inductive, noise, wherein an electromagnetic interference suppressing body is interposed between said circuit board and said active element, said electromagnetic interference suppressing body comprising a conductive support element and a non-conductive soft magnetic layer overlying at least one of the surfaces of said conductive support element,

Said non-conductive soft magnetic layer comprising soft magnetic powder and organic binder, said soft magnetic powder being at least one selected from the group consisting of flat needle-like powder dispersed in said organic binder, said soft magnetic powder being aligned parallel to said support element within said non-conductive soft magnetic layer, and wherein said soft magnetic powder comprises iron and at least one of nickel, aluminum, and silicon, each of the particles oxidized at its surface.

15. An electronic equipment claimed in claim **14**, wherein said electromagnetic interference suppressing body further comprises a dielectric layer overlying said non-conductive soft magnetic layer.

16. An electronic equipment claimed in claim **14**, wherein said electromagnetic interference suppressing body further comprises a dielectric layer interposed between said conductive support element and non-conductive soft magnetic layer.

17. An electronic equipment claimed in claim **14**, wherein said non-conductive soft magnetic layer further comprises dielectric powder.

18. An electronic equipment claimed in claim **15** or **16**, wherein said dielectric layer comprises dielectric powder and organic binder.

19. An electronic equipment claimed in claim **14**, wherein said conductive support element is one selected from a conductive plate, a wire netting conductive plate, and a textile made of conductive fiber.

20. An electronic equipment claimed in claim 14, wherein said conductive support element comprises a non-conductive base member and a conductive layer overlying at least one of surfaces of said non-conductive base member.

21. An electronic equipment claimed in claim 16, wherein said conductive support element comprises a non-conductive base member and a soft magnetic metal thin layer overlying at least one of surfaces of said non-conductive base member.

22. An electronic equipment claimed in claim 20 or 21, wherein said non-conductive base member is made of one of a non-conductive soft magnetic layer and a dielectric layer.

23. An electronic equipment claimed in claim 14, wherein said conductive support element comprises conductive fine powder and organic binder.

24. An electronic equipment claimed in claim 14, wherein said conductive support element comprises a non-conductive base member and a conductive layer overlying at least one of surfaces of said non-conductive base member, said conductive layer comprising conductive fine powder and organic binder.

25. An electronic equipment claimed in claim 14, wherein said conductive support element is a conductive soft magnetic support element having soft magnetic property.

26. An electronic equipment claimed in claim 14, wherein said conductive soft magnetic support element is one selected from a soft magnetic metal plate, a wire netting metal plate, and a textile made of soft magnetic metal fiber.

* * * * *

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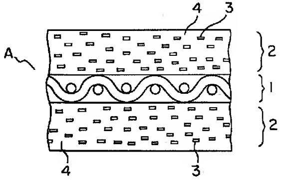
最終頁に続く

(54)【発明の名称】　電磁波干渉抑制体

(57)【要約】
【目的】　電磁波の透過に対して導電性のシールド材と同等の遮蔽効果をもち、電磁波の反射に対して反射による電磁結合を助長させせることのないこと。
【構成】　導電性支持体１と、該導電性支持体１の少なくとも一方面に設けた絶縁性軟磁性体層２とを有し、該絶縁性軟磁性体層２は軟磁性体粉末３と有機結合剤４とを含む。前記絶縁性軟磁性体層２の上面もしくは下面に誘電体層１０を有している。前記導電性支持体１が、軟磁性を有する導電性軟磁性支持体である。



【特許請求の範囲】

【請求項１】　電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有し、該絶縁性軟磁性体層は軟磁性体粉末と有機結合剤とを含むことを特徴とする電磁波干渉抑制体。

【請求項２】　電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有すると共に、該絶縁性軟磁性体層の少なくとも一方面に設けられた誘電体層を有し、前記絶縁性軟磁性体層は軟磁性体粉末と有機結合剤とを含み、前記誘電体層は誘電体粉末と有機結合剤とを含むことを特徴とする電磁波干渉抑制体。

【請求項３】　電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有し、該絶縁性軟磁性体層は、軟磁性体粉末、誘電体粉末、及び有機結合剤を含むことを特徴とする電磁波干渉抑制体。

【請求項４】　前記軟磁性体粉末が、偏平状および／または針状の粉末であることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項５】　前記導電性支持体が、導電体板、網目状導電体板、もしくは導電性繊維の織物であることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項６】　前記導電性支持体が、絶縁基材と該絶縁基材の少なくとも一方の面に蒸着成膜された導電性膜とからなることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項７】　前記導電性支持体が、絶縁基材と該絶縁基材の少なくとも一方面に蒸着成膜された軟磁性金属薄膜とからなることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項８】　前記絶縁基材が、請求項１、２又は３記載の前記絶縁性軟磁性体層もしくは請求項２記載の誘電体層で代用されていることを特徴とする請求項６又は７記載の電磁波干渉抑制体。

【請求項９】　前記導電性支持体が、導電性微粉末と有機結合剤とからなることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項１０】　前記導電性支持体が、絶縁基材と、該絶縁基材の少なくとも一方の面上に設けられた導電体層とを有し、該導電体層は導電性微粉末と有機結合剤とを含むことを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項１１】　前記導電性支持体が、軟磁性を有する導電性軟磁性支持体であることを特徴とする請求項１、２又は３記載の電磁波干渉抑制体。

【請求項１２】　前記導電性軟磁性支持体が、軟磁性金属板、網目状軟磁性金属板、もしくは軟磁性金属繊維の織物であることを特徴とする請求項１０記載の電磁波干渉抑制体。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は電磁波干渉抑制体に関し、特に高周波領域において不要電磁波の干渉によって生じる電磁障害を抑制するために用いられる電磁波干渉抑制体に関する。

【０００２】

【従来の技術】近年、デジタル電子機器をはじめ高周波を利用する電子機器類が普及しており、中でも準マイクロ波帯域を使用する通信機器類の普及がめざましい。例えば、携帯電話に代表される移動体通信機器は、特に小型化・軽量化の要求が顕著であり、高密度実装化が最大の技術課題の一つとなっている。

【０００３】したがって、過密に実装された電子部品類やプリント配線には、信号処理速度の高速化も図られているため、静電及び電磁結合による線間結合の増大化や放射ノイズによる干渉などが生じ、電子機器類の正常な動作を妨げる事態が少なからず生じている。

【０００４】このようないわゆる電磁障害に対して、従来は回路の出力端子毎にローパスフィルタ等を接続し、不要な高周波電流を抑制したり、問題となる回路を遠ざけるような方策を講じる等で電磁障害の原因となる電磁結合、不要輻射や伝導ノイズ等を抑制していた。

【０００５】これら高周波電子機器のさらなる小型、軽量化を実現する具体策として、例えば、一枚のプリント配線基板に異なる回路を混在（例えば、電力回路と小信号回路）させたり、回路ごとに小基板化し、それらを重ね合わせて実装するといった手段が取られることが多くなってきている。

【０００６】しかし、特に、複数の配線基板を重ね合わせて実装する場合においては、部品間や配線基板間の電磁波干渉に由来する電磁障害の起こりうる可能性が極めて高くなり、何等かの対策が不可欠となる。これらの配線基板間における干渉の対策手段としては、一般に、導電性のシールド材（銅板、アルミニウム板等）を配線基板間に挿入することが行われている。配線基板では、部品実装密度が高くなっているために、高周波磁界波はノイズ源に対して低インピーダンスとなっており、配線基板の相互間隔も接近して配置されている。

【０００７】

【発明が解決しようとする課題】しかしながら、上述した配線基板では、ノイズ源となる一方の配線基板に対向する他方の配線基板に対しての遮蔽効果は期待できるものの、同じ基板面に対しては、不要輻射の反射が生じてしまい、ノイズ源側の同一配線基板内での二次的な電磁結合が助長されるという問題がある。

【０００８】それ故に本発明の課題は、電磁波の透過に対しては、導電性のシールド材と同等の遮蔽効果をも

ち、電磁波の反射に対しては、少なくとも反射による電磁結合を助長させることのない電磁波干渉抑制体を提供することにある。

【0009】

【課題を解決するための手段】本発明によれば、電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有し、該絶縁性軟磁性体層は軟磁性体粉末と有機結合剤とを含むことを特徴とする電磁波干渉抑制体が得られる。

【0010】また、本発明によれば、電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有すると共に、該絶縁性軟磁性体層の少なくとも一方面に設けられた誘電体層を有し、前記絶縁性軟磁性体層は軟磁性体粉末と有機結合剤とを含み、前記誘電体層は誘電体粉末と有機結合剤とを含むことを特徴とする電磁波干渉抑制体が得られる。

【0011】また、本発明によれば、電磁障害を抑制する電磁波干渉抑制体において、導電性支持体と、該導電性支持体の少なくとも一方面に設けられた絶縁性軟磁性体層とを有し、該絶縁性軟磁性体層は、軟磁性体粉末、誘電体粉末、及び有機結合剤を含むことを特徴とする電磁波干渉抑制体が得られる。

【0012】また、本発明によれば、前記軟磁性体粉末が、偏平状および／または針状の粉末であることを特徴とする電磁波干渉抑制体が得られる。

【0013】また、本発明によれば、前記導電性支持体が、導電体板、網目状導電体板、もしくは導電性繊維の織物であることを特徴とする電磁波干渉抑制体が得られる。

【0014】また、本発明によれば前記導電性支持体が、絶縁基材と該絶縁基材の少なくとも一方の面に蒸着成膜された導電性膜とからなることを特徴とする電磁波干渉抑制体が得られる。

【0015】また、本発明によれば、前記導電性支持体が、絶縁基材と該絶縁基材の少なくとも一方面に蒸着成膜された軟磁性金属薄膜とからなることを特徴とする電磁波干渉抑制体が得られる。

【0016】また、本発明によれば、前記導電性支持体が、導電性微粉末と有機結合剤とからなることを特徴とする電磁波干渉抑制体が得られる。

【0017】また、本発明によれば、前記導電性支持体が、絶縁基材と、該絶縁基材の少なくとも一方の面上に設けられた導電体層とを有し、該導電体層は導電性微粉末と有機結合剤とを含むことを特徴とする電磁波干渉抑制体が得られる。

【0018】また、本発明によれば、前記導電性支持体が、軟磁性を有する導電性軟磁性支持体であることを特徴とする電磁波干渉抑制体が得られる。

【0019】また、本発明によれば、前記導電性軟磁性支持体が、軟磁性金属板、網目状軟磁性金属板、もしくは軟磁性金属繊維の織物であることを特徴とする電磁波干渉抑制体が得られる。

【0020】

【作用】本発明の電磁波干渉抑制体は、導電性基材（導電性支持体）の片面もしくは両面に絶縁性の軟磁性体層が設けられたものを基本構成としている。即ち、複数の配線基板が重ね合って実装されている場合においては、電磁波干渉抑制体を配線基板間に挿入することにより、導電性基材がノイズ源となる一方の配線基板に対向する他方の配線基板に対して遮蔽効果が働き電磁波干渉が抑制される。

【0021】一方、導電性基材を配線基板間に挿入することにより生じる不要輻射の反射による電磁結合の増大化は、軟磁性体粉末と有機結合剤からなる絶縁性軟磁性体層により抑制される。この絶縁性軟磁性体層は、本来、導電性物質である軟磁性金属を微細粉末化し、絶縁性の有機結合剤と混練・分散することにより絶縁層となっていると共に、誘電体層の存在ないし誘電体粉末の軟磁性層への混合により空間とのインピーダンス整合が図られるため、軟磁性層表面での不要輻射の反射が起こり難くなる。

【0022】また、軟磁性体粉末の形状が偏平状もしくは針状であるために、形状磁気異方性が出現し、高周波領域にて磁気共鳴に基づく複素透磁率の増大化が生じ、不要輻射成分が効率的に吸収、抑制される。

【0023】

【実施例】次に、本発明の電磁波干渉抑制体の第１実施例を図１を参照して説明すると、電磁波干渉抑制体Aは、導電性支持体（もしくは軟磁性を有する導電性軟磁性支持体）１と、この導電性支持体１の少なくとも一方面（図１では両面）に設けられた絶縁性軟磁性体層２とを有している。絶縁性軟磁性体層２は偏平状または／および針状の軟磁性体粉末３と有機結合剤４とを含む。

【0024】この電磁波干渉抑制体Aにおいて、導電性支持体１を構成要素とする場合には、例えば、導電性支持体１を導電体板、網目状導電体板、もしくは導電性繊維の織物のうちの一つを選択して用いる。また、導電性軟磁性支持体１を構成要素とする場合には、導電性軟磁性支持体１を軟磁性金属板、網目状軟磁性金属板、もしくは軟磁性金属繊維の織物のうちの一つを選択して用いる。

【0025】第２実施例として本発明の電磁波干渉抑制体Aは、図２に示すように、導電性支持体（もしくは軟磁性を有する導電性軟磁性支持体）１が、絶縁基材５とこの絶縁基材５の少なくとも一方の面に蒸着成膜された導電性薄膜６とを含む。図２では、絶縁基材５の一方の面に蒸着成膜された導電性薄膜６を実施例として示したが、絶縁基材５の両面に導電性薄膜６を蒸着成膜しても

よい。なお、図示しないが、この導電性薄膜6上には、図1に示した絶縁性軟磁性体層2と同様な絶縁性軟磁性体層が設けられるものである。

【0026】第3実施例を図2に基づき本発明の電磁波干渉抑制体Aの例を説明すると、電磁波干渉抑制体Aは、導電性支持体（もしくは軟磁性を有する導電性軟磁性支持体）1が、絶縁基材5とこの絶縁基材5の少なくとも一方面に蒸着成膜された軟磁性金属薄膜7とを含む。図2では、絶縁基材5の一方面に蒸着成膜された軟磁性金属薄膜7を実施例として示したが、絶縁基材5の両面に軟磁性金属薄膜7を蒸着成膜してもよい。なお、図示しないが、この軟磁性金属薄膜7上には、図1に示した絶縁性軟磁性体層2と同様な絶縁性軟磁性体層が設けられるものである。

【0027】第4実施例として本発明の電磁波干渉抑制体Aは、図3に示すように、導電性支持体1が導電性微粉末8と有機結合剤4とからなる。この導電性支持体1の少なくとも一方面には、図1で示した絶縁性軟磁性体層2と同様な絶縁性軟磁性体層が設けられるものである。

【0028】第5実施例として本発明の電磁波干渉抑制体Aは、図4に示すように、導電性支持体1が、絶縁基材5とこの絶縁基材5の少なくとも一方の面上に設けられた導電体層9とを有している。この導電性支持体1の少なくとも一方の面には、図1で示した絶縁性軟磁性体層2と同様な絶縁性軟磁性体層が設けられるものである。

【0029】第6実施例として本発明の電磁波干渉抑制体Aは、図5（a）及び図5（b）に示すように、導電性支持体（もしくは軟磁性を有する導電性軟磁性支持体）1と、導電性支持体1の少なくとも一方面に設けられた絶縁性軟磁性体層2と、絶縁性軟磁性体層2の少なくとも一方面に設けられた誘電体層10とを有している。絶縁性軟磁性体層2は偏平状（もしくは針状）の軟磁性体粉末3と有機結合剤4とを含む。誘電体層10は、誘電体粉末11と有機結合剤4とを含む。即ち、図5（a）の電磁波干渉抑制体Aは、導電性支持体1と誘電体層10との間に絶縁性軟磁性体層2が介在されている。また、図5（b）の電磁波干渉抑制体Aは、導電性支持体1と絶縁性軟磁性体層2との間に誘電体層10が介在されている。

【0030】第7実施例として本発明の電磁波干渉抑制体Aは、図6に示すように、導電性支持体（もしくは軟磁性を有する導電性軟磁性支持体）と、導電性支持体1の少なくとも一方面に設けられた絶縁性軟磁性体層2とを有している。絶縁性軟磁性体層2は、偏平状（もしくは針状）の軟磁性体粉末3、誘電体粉末11、及び有機結合剤4を含む。

【0031】本発明の一つの構成要素である導電性支持体（もしくは導電性軟磁性支持体）1としては、銅薄板、ステンレス薄板、アルミニウム薄板等の金属薄板、及びそれらに微細な穴開け加工を施したいわゆるパンチングメタル、或いは薄板に微細な切れ目を施した後に、延伸加工したいわゆるエキスパンドメタル、或いは細線状の導体を網目状に加工した金網等を使用できる。

【0032】同様の形態にて材質のみが軟磁性を有するパーマロイ或いは鉄－珪素鋼等に代えれば、特に比較的低い周波数での電磁干渉抑制効果の高まりが期待できるので、用途に応じて選択するのが望ましい。

【0033】本発明の構成要素のもう一つである絶縁性軟磁性層2の形成に用いることのできる偏平状（もしくは針状）の軟磁性体粉末3としては、高周波透磁率の大きな鉄アルミ珪素合金（センダスト）、鉄ニッケル合金（パーマロイ）をその代表的素材として挙げることができ、粉末のアスペクト比は十分に大きい（おおよそ5：1以上）ことが望ましい。

【0034】絶縁性軟磁性層2の形成に用いる有機結合剤4としては、ポリエステル系樹脂、ポリ塩化ビニル系樹脂、ポリビニルブチラール樹脂、ポリウレタン樹脂、セルロース系樹脂、ニトリルーブタジエン系ゴム、スチレンーブタジエン系ゴム等の熱可塑性樹脂或いはそれらの共重合体、エポキシ樹脂、フェノール樹脂、アミド系樹脂、イミド系樹脂等の熱硬化性樹脂等を挙げることができる。

【0035】また、絶縁基材5として例えば、ポリイミド基材等の片面もしくは両面に金属、磁性金属、導電性カーボン、有機導電体等をスパッタ法、真空蒸着法、化学蒸着（CVD）法等の蒸着法により成膜した導電性基材もしくは導電性磁性基材も本発明の支持体として用いることができる。

【0036】また銀粉、銅粉等の金属微粉末もしくは導電性カーボンブラック、導電性酸化チタン等を有機結合剤4とともに混練、分散しこれをシート化したもの、或いは直接シート化せずにポリイミド基材等の絶縁基材5の片面もしくは両面にドクターブレード法、グラビアコート法或いはリバースコート法等の手段により成膜したものを導電性支持体（もしくは導電性軟磁性支持体）1として使用できる。

【0037】さらに、第6実施例で述べた本発明のもう一つの構成要素である誘電体層10、もしくは絶縁性軟磁性体層2の形成に用いることのできる誘電体粉末11としては、高周波領域での誘電率が大きく、かつ誘電率の周波数特性が比較的平坦なものが好ましい。一例として、チタン酸バリウム系セラミック、チタン酸ジルコン酸系セラミック、鉛ペロブスカイト系セラミック等を挙げることができる。

【0038】次に、本発明の電磁波干渉制御体Aによる抑制効果の測定について以下に検証する。図7は、本発明の電磁波干渉制御体Aの一応用例であり、電磁波干渉制御体Aを互いに対向して配置された2つの配線基板2

１，２３間に実装した状態をを示している。

【００３９】配線基板２１，２３には各々複数個の電子部品２４、２５、２６が実装され、配線基板２１，２３の電子部品２４、２５、２６同士が向かい合うように配線基板２１，２３が対向配置されている。配線基板２１，２３の電子部品２４、２５、２６の間隔は、おおよそ２mm以下である。電磁波干渉抑制体Aは配線基板２１，２３間に挿入される。本発明の効果を検証するにあたっては、図７に示した電磁環境を想定し、以下の抑制効果評価系を準備した。

【００４０】図８（a）及び図８（b）は電磁波干渉抑制体Aの特性評価系を示す。図８（a）は、透過レベル［dB］を測定するための評価系であり、図８（b）は、結合レベル［dB］を測定するための評価系である。各々の場合とも、電磁界波源用発振器２８及び電磁界強度測定器（受信用素子）２９には、ループ径２mm以下の電磁界送信用微小ループアンテナ３１，電磁界受信用微小ループアンテナ３２を用いている。透過レベルもしくは結合レベルの測定にはネットワークアナライザ（図示せず）を使用した。

【００４１】［検証例１］導電性支持体１として２４メッシュのステンレス網を用い、この導電性支持体１の両面に乾燥、硬化後の全厚寸法が１．２mmとなるように下記の<組成１>の配合からなる軟磁性体ペーストをドクターブレード法により塗工し、８５℃にて２４時間キュアリングを行い評価用試料①を得た。なお、得られた評価用試料①を振動型磁力計並びに走査型電子顕微鏡を用いて解析したところ、磁化容易軸及び磁性粒子配向方向は試料面内方向であった。

【００４２】

<組成１>

偏平状軟磁性体微粉末　……　９０重量部
　組　成：Fe－Al－Si合金
　平均粒径：１０μm
　アスペクト比：＞５
有機結合剤
　ポリウレタン樹脂　……　８重量部
　硬化剤（イソシアネート化合物）　……　２重量部
溶剤（シクロヘキサノンとトルエンとの混合物）　……　４０重量部

［検証例２］導電性支持体１として［検証例１］のステンレス網を用いる代わりに、軟磁性を有する２４メッシュのパーマロイ網（５２Ni－Fe）を用いた以外は、［検証例１］と同様にして評価用試料②を得た。

【００４３】［検証例３］導電性支持体１として７５μmのポリイミドフィルムの両面に厚さが３μmのアルミニウムをスパッタ成膜したものを用いた以外は、［検証例１］と同様にして評価用試料③を得た。

【００４４】［検証例４］導電性支持体１として７５μmのポリイミドフィルムの両面に下記の<組成２>の銀ペーストを乾燥、硬化後の厚さが６μmとなるようにドクターブレード法にて成膜したものを用いた以外は、［検証例１］と同様にして評価用試料④を得た。

【００４５】

<組成２>

銀微粉末　……　９５重量部
　平均粒径：３μm
有機結合剤
　ポリビニルブチラール樹脂　……　４重量部
　硬化剤（イソシアネート化合物）　……　１重量部
溶剤（エチルセルソルブ）　……　３５重量部

［検証例５］導電性支持体として、２４メッシュのステンレス網を用い、この両面に乾燥、硬化後の全厚が１．０mmとなるように以下の<組成３>からなる軟磁性体ペーストをドクターブレード法により塗工し、８５℃にて２４時間キュアリングを行った。その後、得られた軟磁性体層上に以下の<組成４>からなる誘電体ペーストを乾燥、硬化後の厚さが片面当たり１００μmとなるようにドクターブレード法により塗工し、８５℃にて２４時間キュアリングを行い、評価用試料⑤を得た。

【００４６】なお、得られた評価用試料⑤を振動型磁力計並びに走査型電子顕微鏡を用いて解析したところ、磁化容易軸及び磁性粒子配向方向は試料面内方向であった。

【００４７】

<組成３>

偏平状軟磁性体微粉末　……　９０重量部
　組　成：Fe－Al－Si合金
　平均粒径：１０μm
　アスペクト比：＞５

有機結合剤
　ポリウレタン樹脂　……　８重量部
　硬化剤（イソシアネート化合物）　……　２重量部
溶剤（シクロヘキサノンとトルエンとの混合物）　……　４０重量部
＜組成４＞
チタン酸バリウム粉末　……　９０重量部
　　平均粒径：７μｍ
有機結合剤
　ポリウレタン樹脂　……　８重量部
　硬化剤（イソシアネート化合物）　……　２重量部
溶剤（シクロヘキサノンとトルエンとの混合物）　……　４５重量部

［検証例６］導電性支持体１として、２４メッシュのステンレス網を用い、この両面に乾燥、硬化後の全厚が１．２ｍｍとなるように以下の＜組成５＞からなる誘電体粉末含有軟磁性体ペーストをドクターブレード法により塗工し、８５℃にて２４時間キュアリングを行い評価用試料⑥を得た。

【００４８】

＜組成５＞
偏平状軟磁性体微粉末　……　７０重量部
　　組　成：Ｆｅ－Ａｌ－Ｓｉ合金
　　平均粒径：１０μｍ
　　アスペクト比：＞５
チタン酸バリウム粉末　……　２０重量部
　　平均粒径：７μｍ
有機結合剤
　ポリウレタン樹脂　……　８重量部
　硬化剤（イソシアネート化合物）　……　２重量部
溶剤（シクロヘキサノンとトルエンとの混合物）　……　４５重量部

［比較例１］厚さが１００μｍの銅板を比較用試料①とした。

【００４９】［比較例２］略球状の形状を有し、平均粒径が３０μｍの鉄粉８０重量部をニトリルゴム２０重量部に練り込み、厚さ１．２ｍｍのシート状を形成し、これを比較用試料②とした。

【００５０】評価用試料①～⑥及び比較用試料①及び②の透過レベル及び結合レベルを図８（ａ）及び図８（ｂ）に示す評価系にて測定した結果を図９（ａ）及び図９（ｂ）、図１０（ａ）及び図１０（ｂ）に示す。図９（ａ）及び図９（ｂ）は、比較用試料①及び②の電磁波干渉抑制効果の周波数特性を示し、図９（ａ）は透過レベル［ｄＢ］の周波数ｆ［ＧＨｚ］特性である。ここで、透過レベルの基準は、電磁波干渉抑制体Ａがない状態の電磁界強度とした。図９（ｂ）は結合レベル［ｄＢ］の周波数ｆ［ＧＨｚ］特性である。ここで、結合レベルの基準は、電磁波干渉抑制体Ａがない状態の電磁界強度とした。

【００５１】図１０（ａ）及び図１０（ｂ）は、評価用試料①、④、⑤及び⑥の電磁波干渉抑制効果の周波数特性を示し、図１０（ａ）は透過レベル［ｄＢ］の周波数ｆ［ＧＨｚ］特性である。ここで、透過レベルの基準は、電磁波干渉抑制体Ａがない状態の電磁界強度とした。図１０（ｂ）は結合レベル［ｄＢ］の周波数ｆ［ＧＨｚ］特性である。ここで、結合レベルの基準は、電磁波干渉抑制体Ａがない状態の電磁界強度とした。図１１には、評価用試料①～⑥及び比較用試料①及び②の周波数８００ＭＨｚにおける透過レベル及び結合レベルを示した。

【００５２】図９（ａ）及び図９（ｂ）からも判るように、導体（銅箔板）のみの場合［比較例１］では、透過レベルは大幅に低下するものの、結合レベルが増大してしまい問題である。

【００５３】一方、比較例２の軟磁性で形状異方性のほとんどない球状鉄粉をゴムに分散させたものでは、結合レベルが低下する傾向を示しているものの、透過減衰がほとんどなく干渉抑制の効果は極めて薄い。

【００５４】これら従来の電磁波干渉抑制体の結果に対して、本発明の電磁波干渉抑制体Ａ（［検証例１］～［検証例６］）においては、図１０（ａ）、図１０（ｂ）及び図１１からも明白なように、透過レベルが十分低くなっているとともに、結合レベルも増大することがない。

【００５５】したがって、たとえば、図７に示したような複数の電子部品２４、２５、２６を実装する配線基板２１、２３が重ね合わされるように存在する電子機器等において、各々の配線基板２１、２３間に挿入することで同一配線基板２１、２３の電磁波干渉を抑制すること

が可能となる。

【００５６】

【発明の効果】以上、実施例により説明したように、導電性支持体もしくは導電性軟磁性支持体の少なくとも一方面に、偏平もしくは針状の軟磁性体粉末と有機結合剤からなる絶縁性軟磁性体層を設けてなる電磁波干渉抑制体は、導体を挿入したことにより生じる不要輻射の反射を増大化させることなく透過減衰を大きく確保することができ、移動体通信機器をはじめとする高周波電子機器類内での電磁波干渉を抑止することが可能となる。

【００５７】なお、本発明の電磁波干渉抑制体は、その構成要素からわかるように容易に可撓性を付与することが可能であり、複雑な形状への対応や厳しい耐振動、衝撃要求への対応が可能である。

【図面の簡単な説明】

【図１】本発明の電磁波干渉抑制体の第１実施例を示す一部断面図である。

【図２】本発明の電磁波干渉抑制体における導電性支持体の第２実施例、及び第３実施例を共通の構成で示す一部断面図である。

【図３】本発明の電磁波干渉抑制体における導電性支持体の第４実施例を示す一部断面図である。

【図４】本発明の電磁波干渉抑制体における導電性支持体の第５実施例を示す一部断面図である。

【図５】本発明の電磁波干渉抑制体の第６実施例を示し、（ａ）及び（ｂ）は導電性支持体上に設けられる２つの層が互いに逆の関係になるように設けられた状態の例を示す各一部断面図である。

【図６】本発明の電磁波干渉抑制体の第７実施例を示す一部断面図である。

【図７】本発明の電磁波干渉抑制体を配線基板間に実装した状態の応用例を示す概略断面図である。

【図８】電磁波干渉抑制体の特性評価に用いた評価系を示し、（ａ）は透過レベルを測定するための評価系概略図、（ｂ）は結合レベルを測定するための評価系概略図である。

【図９】比較用試料を図８（ａ）及び図８（ｂ）の評価系にて測定した電磁波干渉抑制効果の周波数依存性を示し、（ａ）は透過レベルの周波数特性グラフ、（ｂ）は結合レベルの周波数特性グラフである。

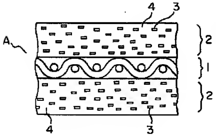
【図１０】評価用試料を図８（ａ）及び図８（ｂ）の評価系にて測定した電磁波干渉抑制効果の周波数依存性を示し、（ａ）は透過レベルの周波数特性グラフ、（ｂ）は結合レベルの周波数特性グラフである。

【図１１】評価用試料及び比較用試料について、周波数８００ＭＨｚにおける各試料の透過レベル及び結合レベルを示すグラフである。

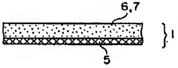
【符号の説明】

１　導電性支持体（導電性軟磁性支持体）
２　絶縁性軟磁性体層
３　軟磁性体粉末
４　有機結合剤
５　絶縁基材
６　導電性薄膜
７　軟磁性金属薄膜
８　導電性微粉末
９　導電体層
１０　誘電体層
１１　誘電体粉末
２１、２３　配線基板
２４、２５、２６　電子部品
２８　電磁界波源用発振器
２９　電磁界強度測定器
３１　電磁界送信用微小ループアンテナ
３２　電磁界受信用微小ループアンテナ
Ａ　電磁波干渉抑制体

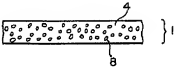
【図１】



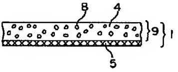
【図２】



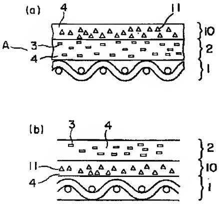
【図３】



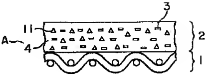
【図４】



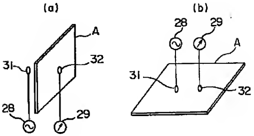
【図5】



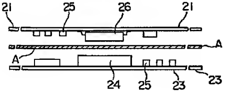
【図6】



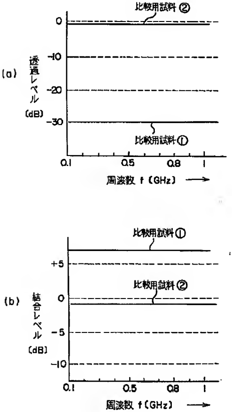
【図8】



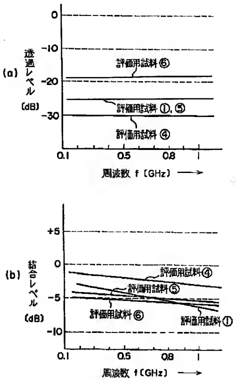
【図7】



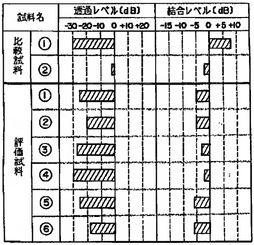
【図9】



【図10】



【図１１】



フロントページの続き

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